BUREAU OF WATER

South Carolina Department of Health and Environmental Control

PRELIMINARY ASSESSMENT OF THE GROUNDWATER CONDITIONS IN PART OF THE PEE DEE REGION, SOUTH CAROLINA

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A PRELIMINARY ASSESSMENT OF THE GROUNDWATER CONDITIONS IN PART OF THE PEE DEE REGION, SOUTH CAROLINA

INTRODUCTION

Concerns among groundwater users about the quantity of groundwater available in the northeastern part of the Coastal Plain of South Carolina resulted in an assessment of the groundwater conditions by the South Carolina Department of Health and Environmental Control (SCDHEC). The study area consists of Florence, Darlington, Marlboro, Dillon, Williamsburg and Marion Counties (fig. 1). This assessment included a review of previous investigations along with a comparison of historical water levels, water-level trends, and current conditions to determine if designation of the Pee Dee area as a Capacity Use Area is warranted (fig. 2).

Section 49-5-60 of the Groundwater Use and Reporting Act states, in part, that... AIn the State where excessive groundwater withdrawal presents potential adverse effects to the natural resources or poses a threat to public health, safety, or economic welfare or where conditions pose a significant threat to the long-term integrity of a groundwater source, including salt water intrusion, the board, after notice and public hearing, in accordance with the Administrative Procedures Act, shall designate a capacity use area. The department, local government authorities, other government agencies, or groundwater withdrawers may initiate the capacity use area designation process. The notice and public hearing must be conducted such that local government authorities, groundwater withdrawers, or the general public may provide comments concerning the capacity use area designation process. A capacity use area must be designated by the board based on scientific studies and evaluation of groundwater resources and may or may not conform to political boundaries. After notice and public hearing, the department shall coordinate the affected governing bodies and groundwater withdrawers to develop a groundwater management plan to achieve goals and objectives stated in Section 49-5-20. In those areas where the affected governing bodies and withdrawers are unable to develop a plan, the department shall take action to develop the plan. The plan must be approved by the board before the department may issue groundwater withdrawal permits for the area.≅

This report documents that several adverse conditions already exist in the area; others are threatening to develop. Various groundwater investigations in the Pee Dee area have documented the existence of excessive water-level declines and an increasing demand on the aquifers as a result of rapid industrial and commercial growth.

GEOHYDROLOGIC FRAMEWORK

Sediments beneath the study area are predominantly Late Cretaceous in age and compose the Black Creek, Middendorf, and Cape Fear aquifer systems as defined by Aucott and others (1987). The sediments consist of sand and clay, and include thin beds of carbonate-cemented

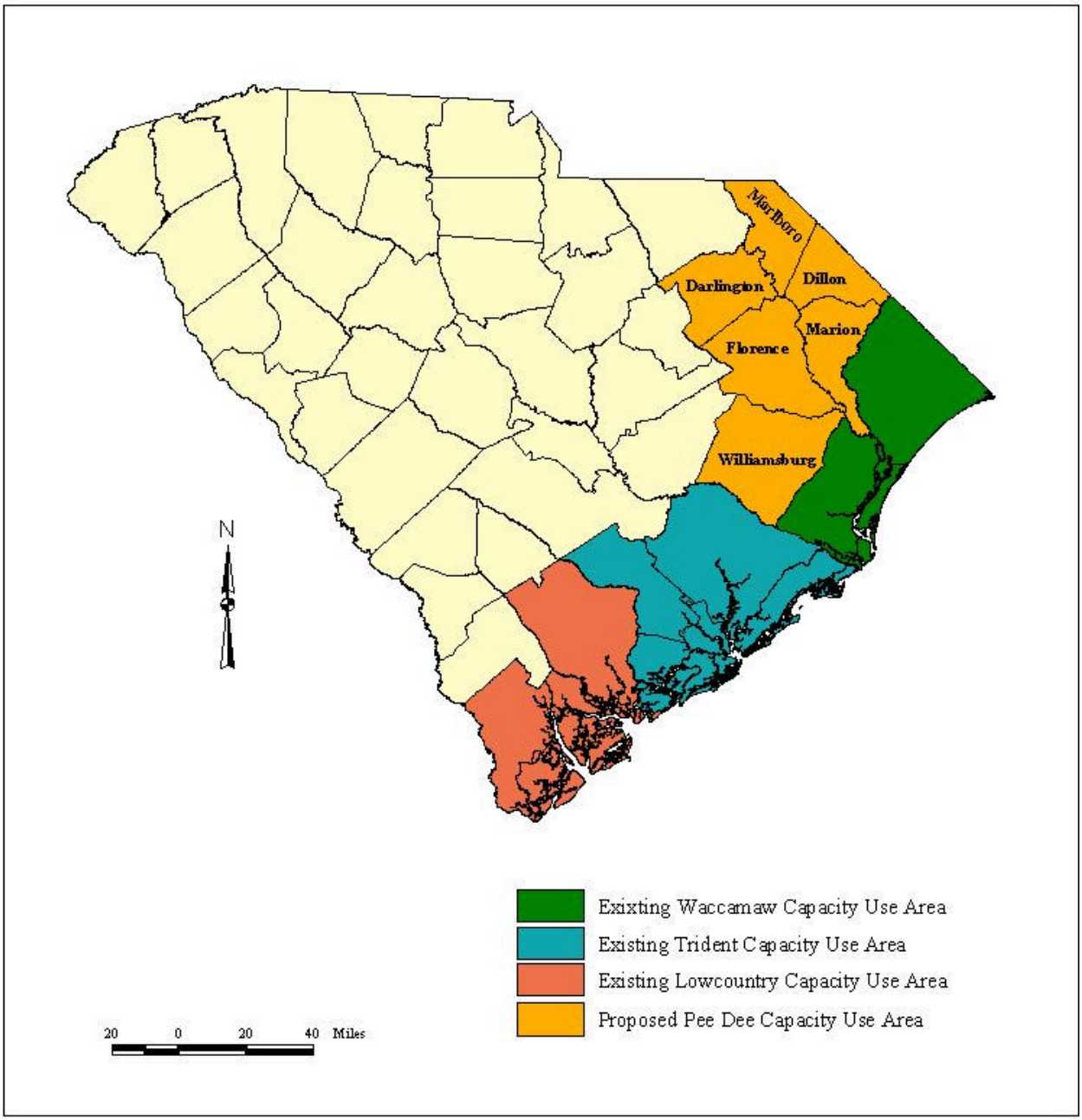

Figure 1. Locations of existing Capacity Use Areas and the proposed Pee Dee Capacity Use Area.

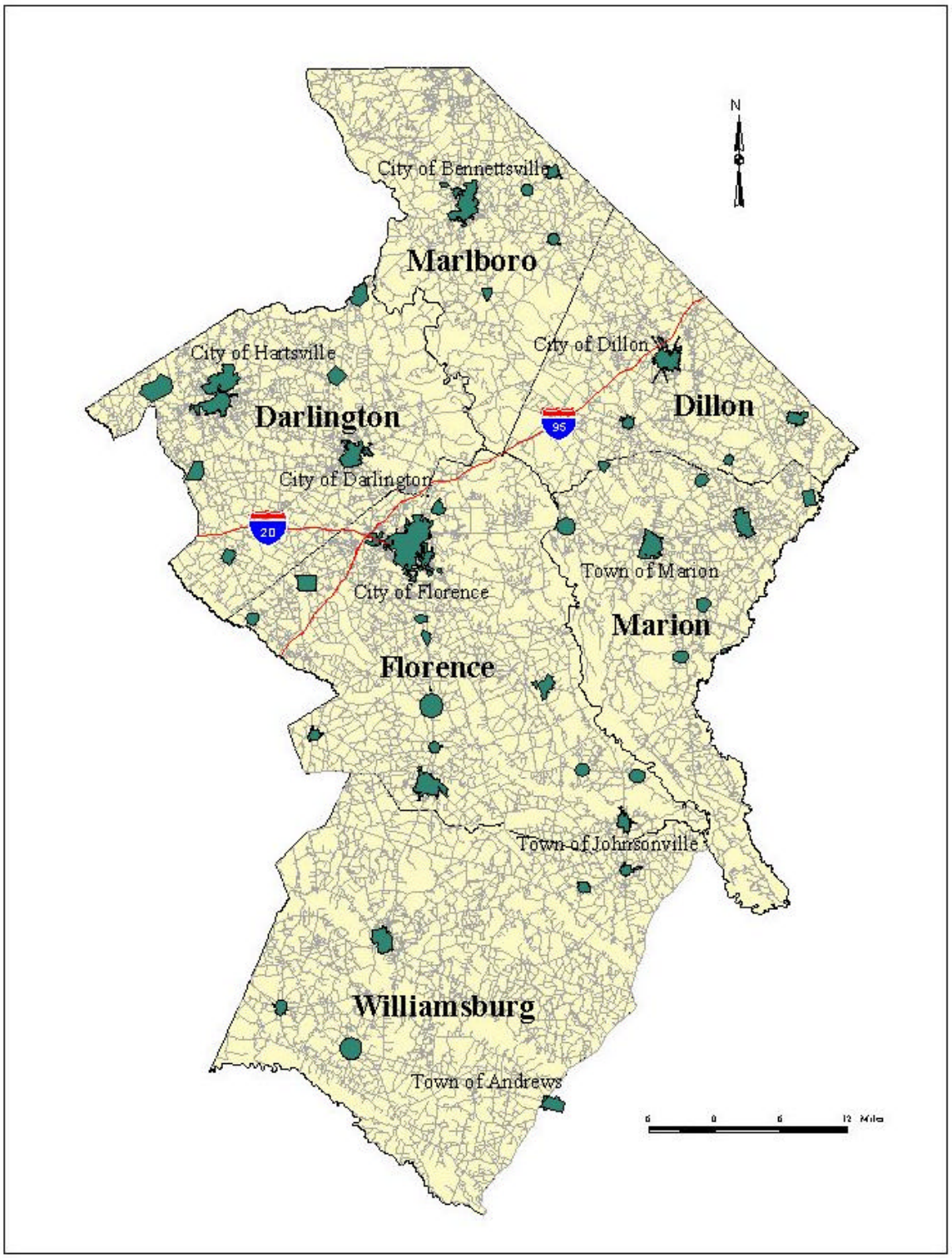

Figure 2. Counties included in the Study Area

sand and sandy carbonate in the upper part of this sedimentary sequence in the eastern part of Florence County. The Late Cretaceous sediments are overlain by sediments of Pliocene and Pleistocene age. These younger sediments have a combined thickness of less than 40 feet and form a surficial aquifer across most of the area (fig. 3). The total thickness of the Cretaceous-age sediments is less than 300 feet in the northwestern portion of the study area and thickens towards the coast to more than 1,300 feet in the southeastern part.

Most of Florence County's groundwater supplies are obtained from the Black Creek aquifer; however, the City of Florence obtains almost all of its water from the Middendorf and Cape Fear aquifers. The Middendorf and the Middendorf/Cape Fear together are the principal groundwater sources for Darlington and Marlboro Counties. Dillon County uses water from the Black Creek and Middendorf or combinations of the two and Marion County taps mainly the Black Creek aquifer.

MIDDENDORF AQUIFER (MIDDENDORF/CAPE FEAR)

Water levels in the Middendorf aquifer have declined substantially from predevelopment (1927) levels as a result of concentrated public supply and industrial usage. The City of Florence utilizes 13 wells completed in the Middendorf for the majority of their potable water supplies. Public supply water usage from the Middendorf for 2001 was reported to be 9.95 MGD. This sustained groundwater withdrawal has resulted in water-level declines and a cone of depression developing around the city.

Aucott (1988) presented a potentiometric map of the Middendorf aquifer for the period prior to development. A portion of this map is shown in figure 4. As can be seen on the map, the water level in Florence was 110 feet above mean sea level. By 1989, the water level in well FLO-0209, located near the center of Florence, had declined to 42 feet ***below*** mean sea level (fig. 5), and by 1996 had declined an additional 33 feet to 75 feet below mean sea level (fig. 6). When measured in November 2001, the water level was 85 feet below mean sea level; a total decline in water levels of 195 feet since the period prior to development.

In 1998, the South Carolina Department of Natural Resources (DNR) published the "South Carolina Water Plan". The plan contained recommendations regarding "Trigger Levels" for various aquifers. A Trigger Level is defined as the minimum water level allowed in an aquifer before the process to declare a Capacity Use Area is automatically initiated. DNR has determined that the Trigger Level is a water-level decline equal to 150 feet below the predevelopment level of an aquifer. Figure 7 shows the Trigger Levels for the Middendorf aquifer. The map indicates that the Trigger Level in the vicinity of Florence is 50 feet below mean sea level. Water levels in the Florence area are currently 85 feet below mean sea level or, 35 feet below the Trigger Level for the Middendorf.

An evaluation of the water budget for the area around Florence aids in understanding the origin of the water being produced from the City's Middendorf wells. Fluxes through the aquifers prior to development were relatively small (fig. 8). Flow through the Black Creek

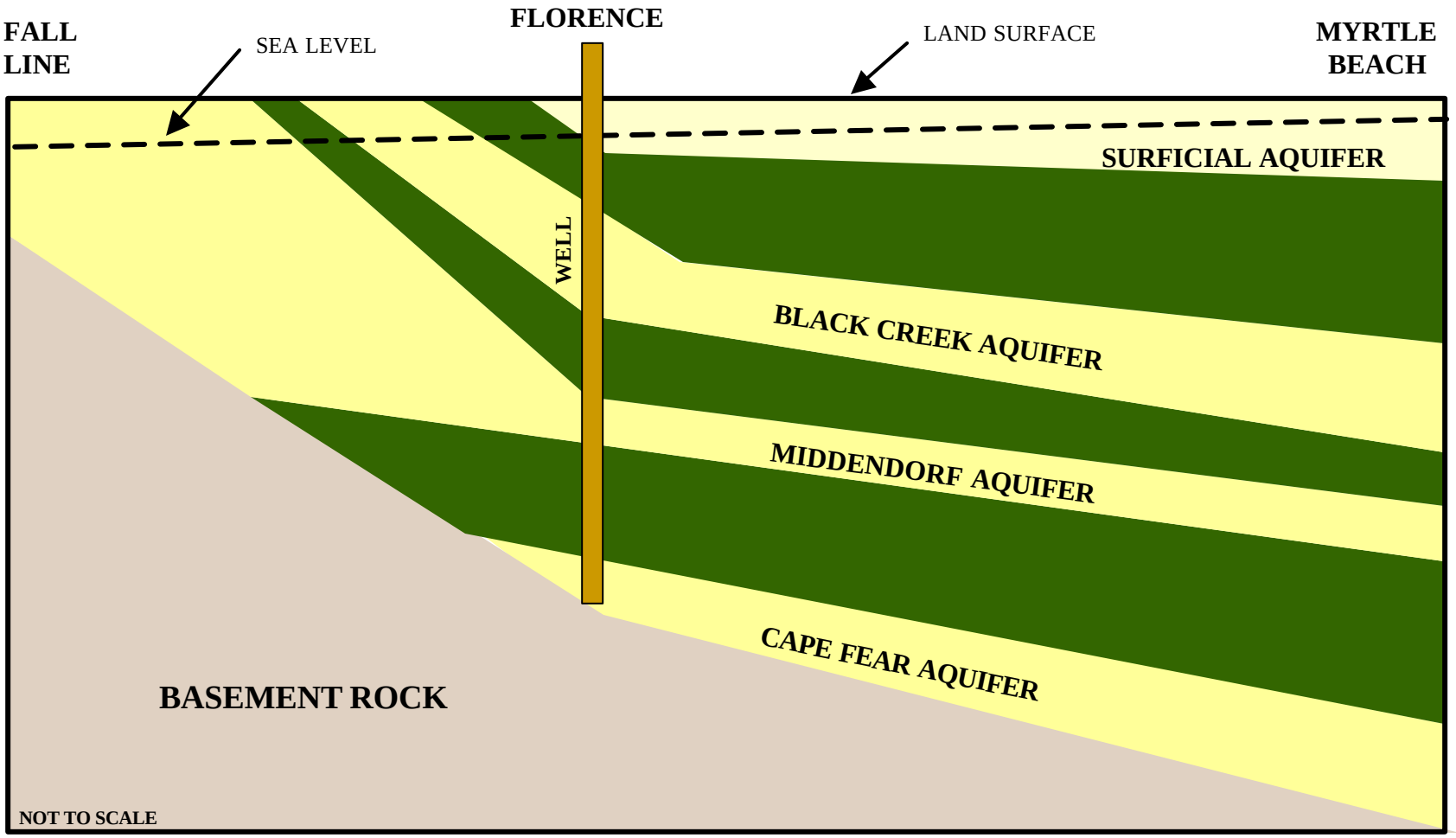

Figure 3. Generalized Hydrologic Section

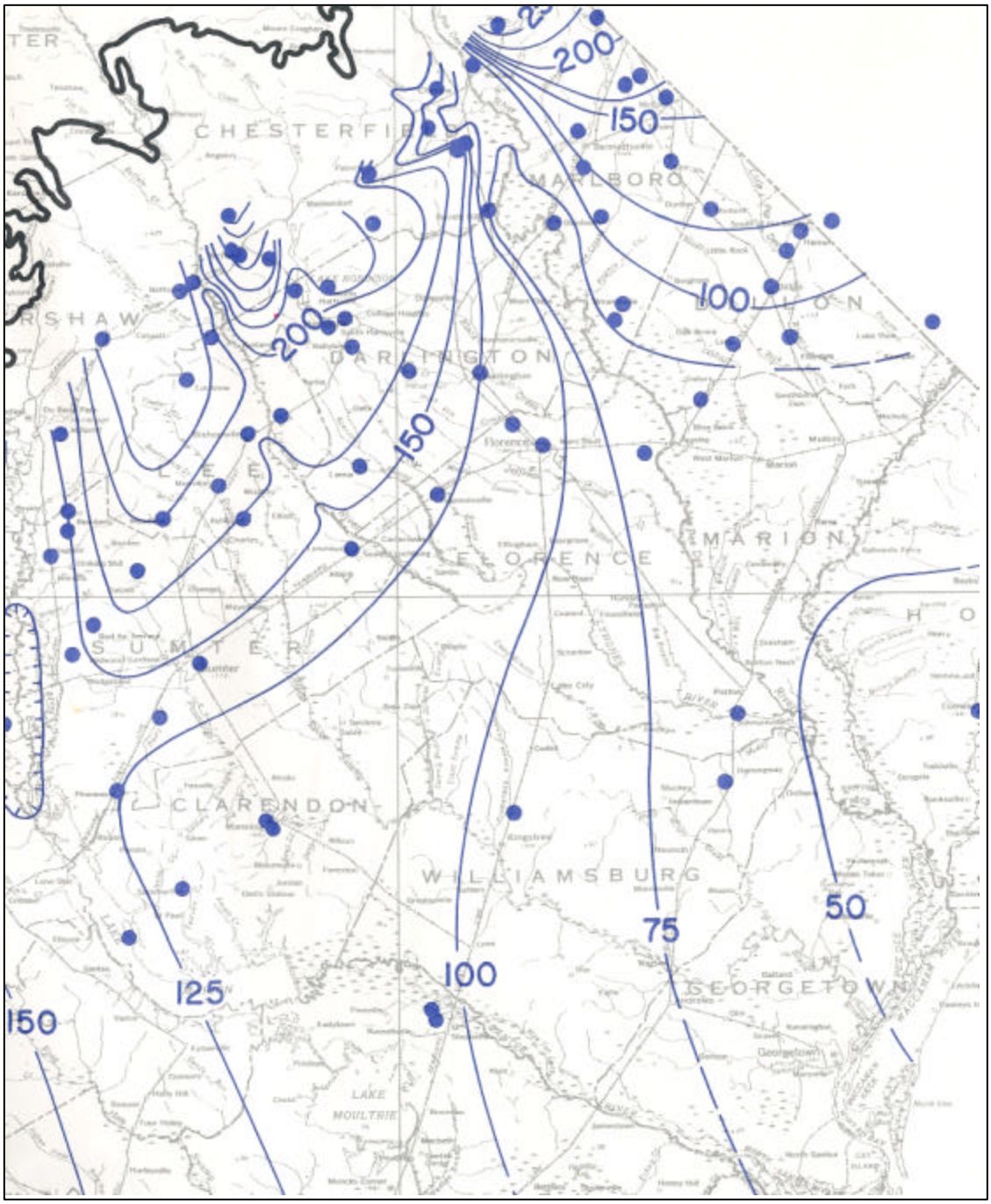

Figure 4. Potentiometric surface of the Middendorf Formation prior to development (from Aucott and Speiran, 1985)

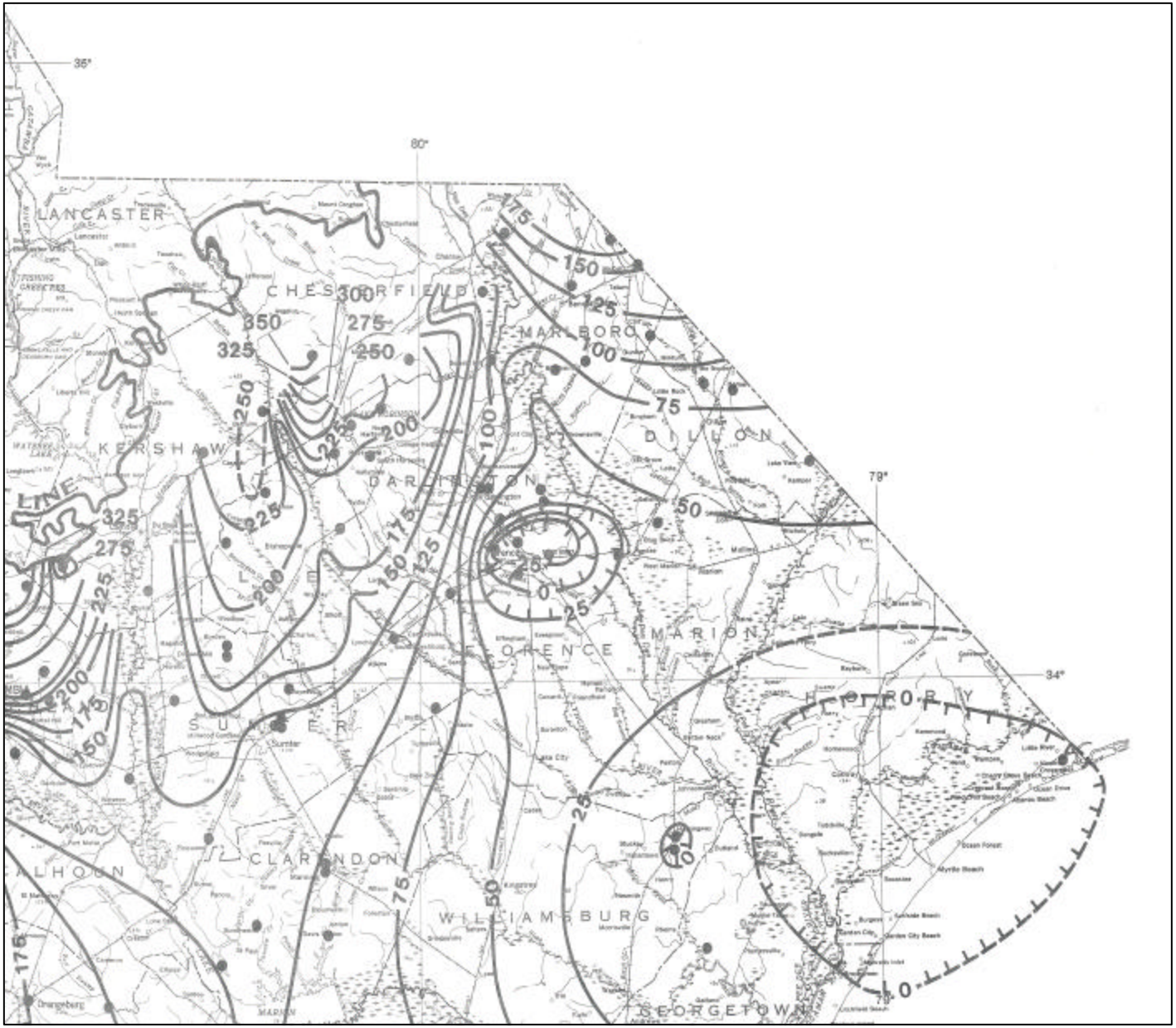

Figure 5. Potentiometric surface of the Middendorf aquifer, November 1989 (from Stringfield and Campbell, 1993)

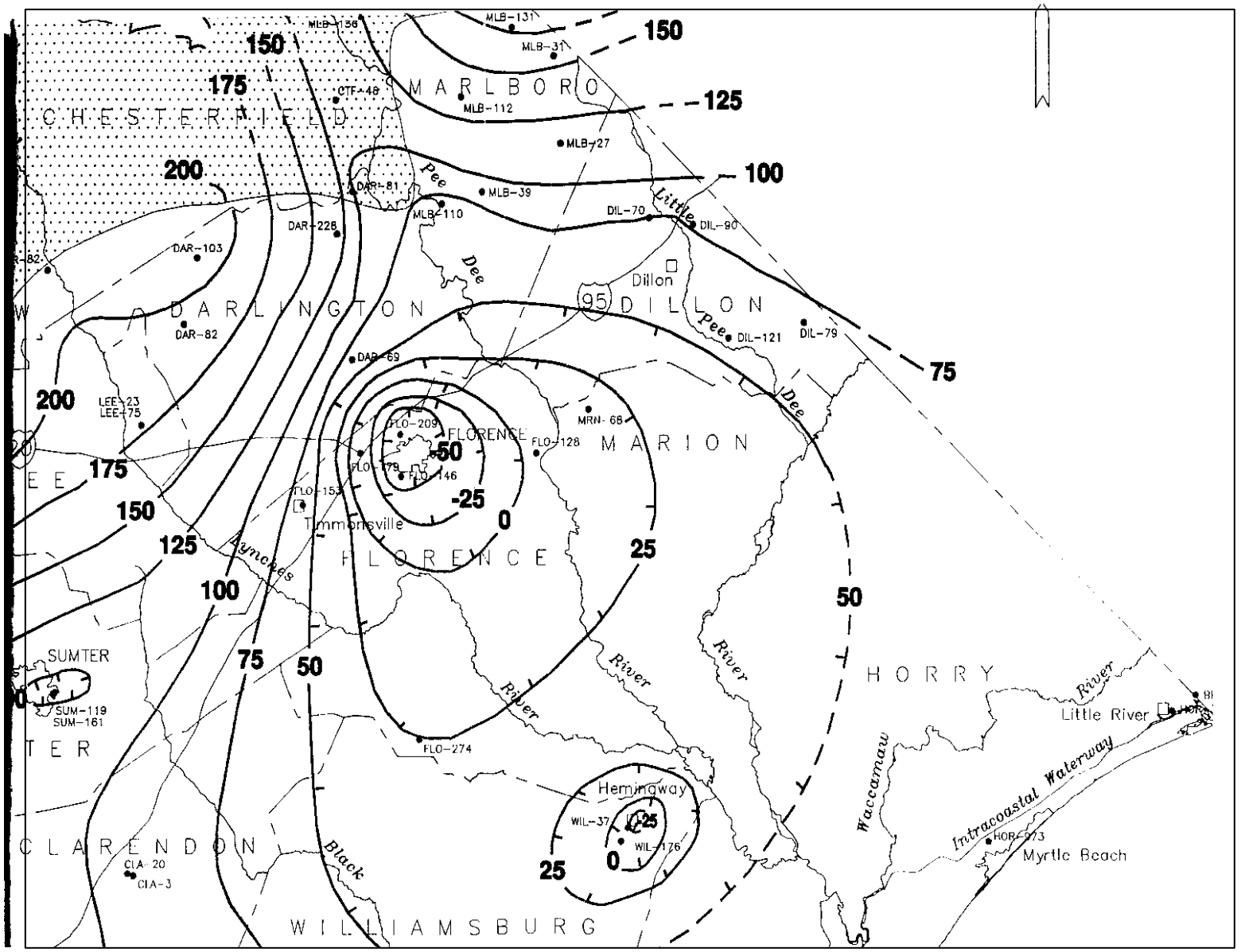

Figure 6. Potentiometric surface of the Middendorf aquifer, November 1996 (from Hockensmith and Waters, 1998)

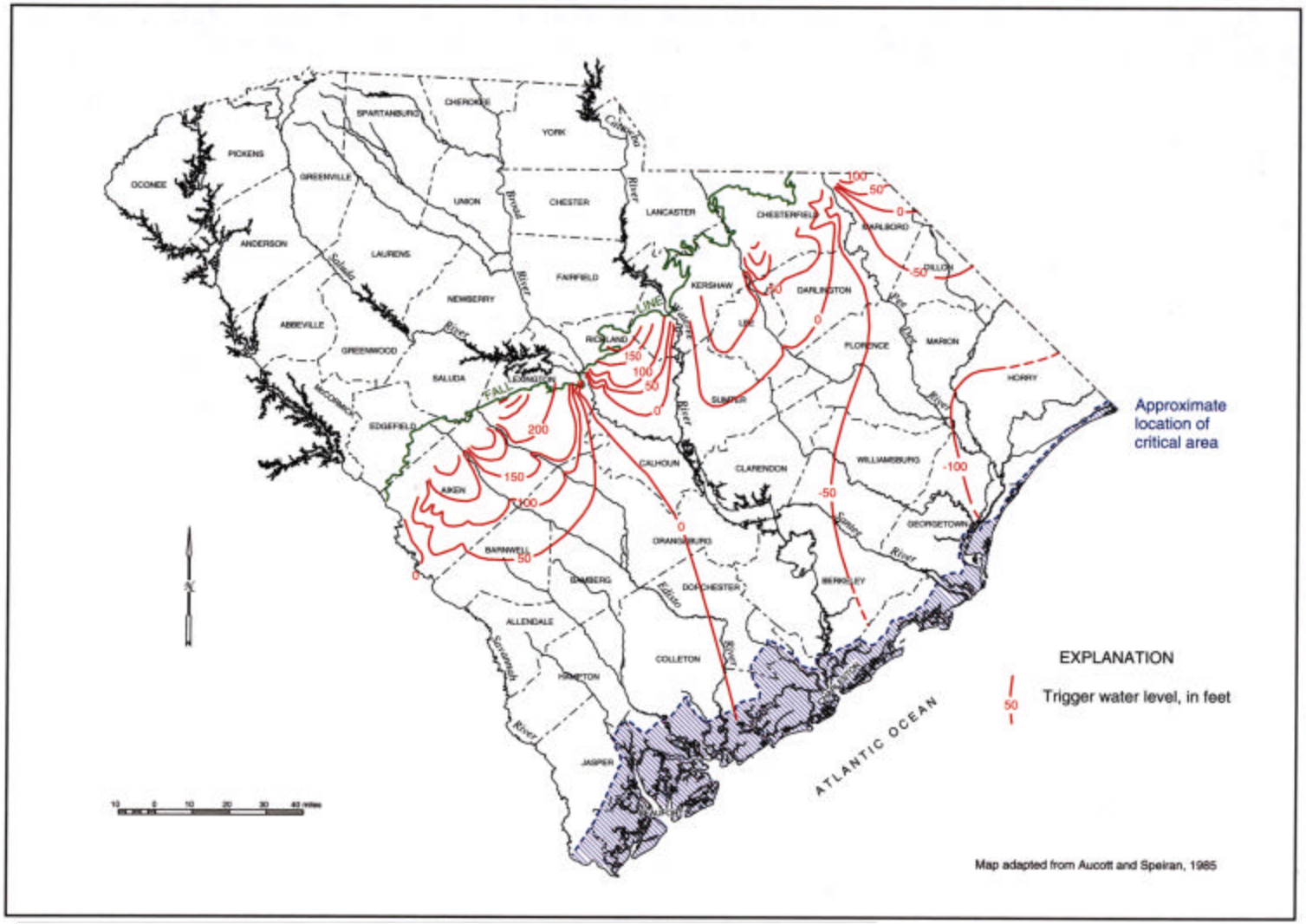

Figure 7. Trigger Levels for the Middendorf aquifer (from SCDNR, 1998)

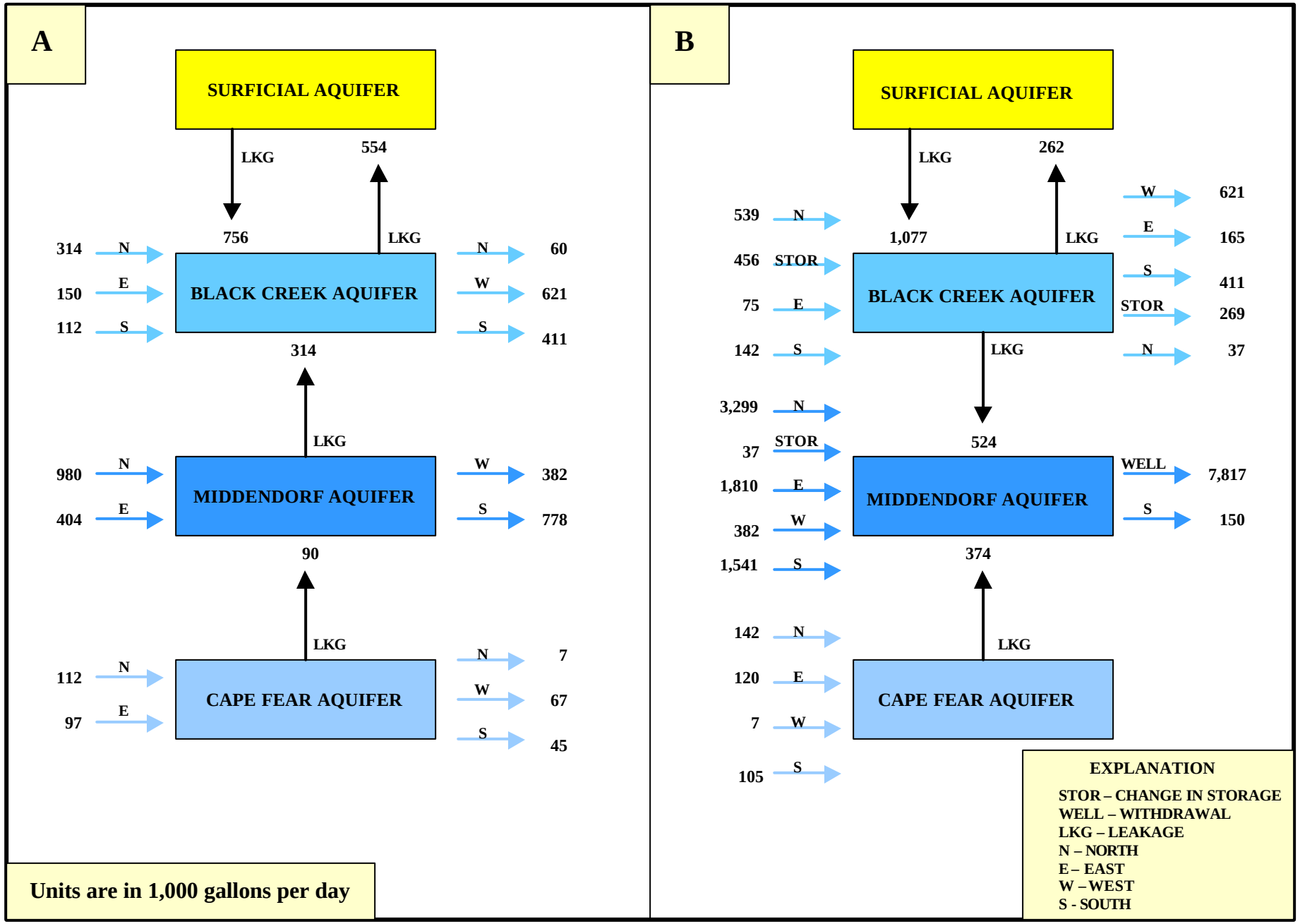

Figure 8. Water Budget for the Florence area for predevelopment (A) and 1989 (B) (modified from Campbell and van Heeswijk, 1996)

amounted to 1,646,000 gallons per day (gpd); 1,474,000 gpd in the Middendorf; and 209,000 gpd in the Cape Fear. There was also leakage from the surficial aquifer to the Black Creek in the amount of 756,000 gpd. By 1989, these fluxes had increased as a result of the amount of water being withdrawn from the Black Creek and Middendorf. The 1989 fluxes were 1,077,000 gpd from the surficial aquifer; 1,765,000 gpd in the Black Creek; 7,967,000 gpd in the Middendorf; and 374,000 in the Cape Fear. The 1989 water budget shows that pumping from the Middendorf aquifer in the Florence area had captured most of the outflow in the area for which the budget was prepared (Campbell, 1996). One noted feature is that pumping from the Middendorf has reversed the hydraulic gradient between the Middendorf and Black Creek (thereby reversing the flow direction, now to downward) and also increased the upward vertical leakage from the Cape Fear. Leakage from the Middendorf to the Black Creek prior to development amounted to 314,000 gpd. In 1989, the flow had reversed and the Black Creek was contributing 524,000 gpd **to** the Middendorf. Vertical leakage upward from the Cape Fear increased from 90,000 gpd to 374,000 gpd. Large net pressure changes occurred prior to 1989, from the time Florence began ground-water withdrawals in 1927. By 1989, a large cone of depression had developed in the Middendorf potentiometric surface and was inducing horizontal flow from all directions toward Florence and vertically from the Black Creek and Cape Fear. Large net pressure changes in the Black Creek indicate that water levels were declining; partially a result of pumping from the Middendorf.

Rodriguez and others (1994) derived a groundwater flow model and an optimization model to create a simulation package to evaluate various groundwater management alternatives for the City of Florence. The groundwater flow model evaluates the response of the aquifer to pumping, and the optimization model determines the quantity and distribution of pumping that produces the least impact on the aquifer. As a result, three management alternatives for Florence's well system were analyzed for a 10-year period (1994 through 2003). These alternatives are: (1) redistribution of pumping, (2) increase amount of available drawdown (the distance between the static water level and some acceptable level in the aquifer; i.e., pump intake, top of well screens, etc.), and (3) add new wells to the system.

The first alternative maintains the current (1994) number of wells and their pump intake location. By redistributing pumping (alternating pumping from various wells), maximum production and minimal drawdowns were sought to be achieved. This alternative showed that production would increase for a few years, then begin to decrease. The decrease in production is the result of cutbacks in pumping required to maintain water levels within the available drawdown. This indicates that the present well system cannot maintain the current level of production if water levels are to be kept above the present pump intake locations.

Alternative 2 increases the amount of available drawdown by lowering the pump intakes to the top of the well screen. This alternative produces a definite increase in production. This increase is not sufficient, however, to satisfy the predicted demand. Water deficits still occur, although at a later time. In this alternative, for example, water deficits occur 3 years later than they do in Alternative 1 for a zero-percent water demand growth.

The third alternative involves adding new wells to the system at four locations. Rodriguez looked at 5 different scenarios:

1. Adding one well at site 1.
2. Adding one well at site 2.
3. Adding one well at site 3.
4. Adding one well at site 4.
5. Adding wells at all four sites.

As expected, the largest increase in production occurs when a well is added at each of the four sites. Although some increase in the total water production is achieved, it is still not sufficient to meet the projected demands.

The City of Florence decided to drill several shallow wells into the Black Creek aquifer. Because of the shallower depth and higher potentiometric heads in the Black Creek, producing water from these wells would be less expensive than from the Middendorf. This would also help alleviate some of the stress on the Middendorf's declining water levels. The increased production would also bring all of the City's water plants up to capacity. Since completing the six shallow wells, water levels around the periphery of the City have recovered about 14 feet; however, water levels near the center of the cone of depression continue to decline.

In 2000, construction began on the Pee Dee Regional Surface Water Treatment Plant which will draw surface water from the Pee Dee river. The design capacity of the plant is 15 million gallons per day (Mgd); however, the start-up capacity will only be 10 Mgd. The reduced capacity is due to the filtration rate. SCDHEC requires a filtration rate of not more than 4 gallons per minute per square foot (gpm/ft^2) of filtration area. In order to meet the 15 Mgd capacity, the filtration rate would have to be increased to 6 gpm/ft^2. The Department will allow this increase, but only after an extensive year-long study proves that the plant can handle the increased capacity. The plant went on-line in mid-December 2002; however, recent flooding of the Pee Dee river washed out the raw water line and the plant was taken off-line on March 26, 2003. In 1995, the City of Florence constructed 4 Middendorf wells to meet peak demands until the surface water plant is in full operation.

BLACK CREEK AQUIFER

Water-level declines in the Black Creek aquifer generally have not been as large as in the Middendorf because withdrawals have been smaller and much less concentrated. Predevelopment water levels in Johnsonville were about 70 to 75 feet above mean sea level (fig 9). When measured in 1995, they were 35 feet below sea level; a decline of about 110 feet. Another area of decline is evidenced in Marion. Predevelopment water levels were about 60 to 65 feet above mean seal level. By 1995, they had declined to 32 feet below sea level; a total decrease of about 95 feet (fig. 10).

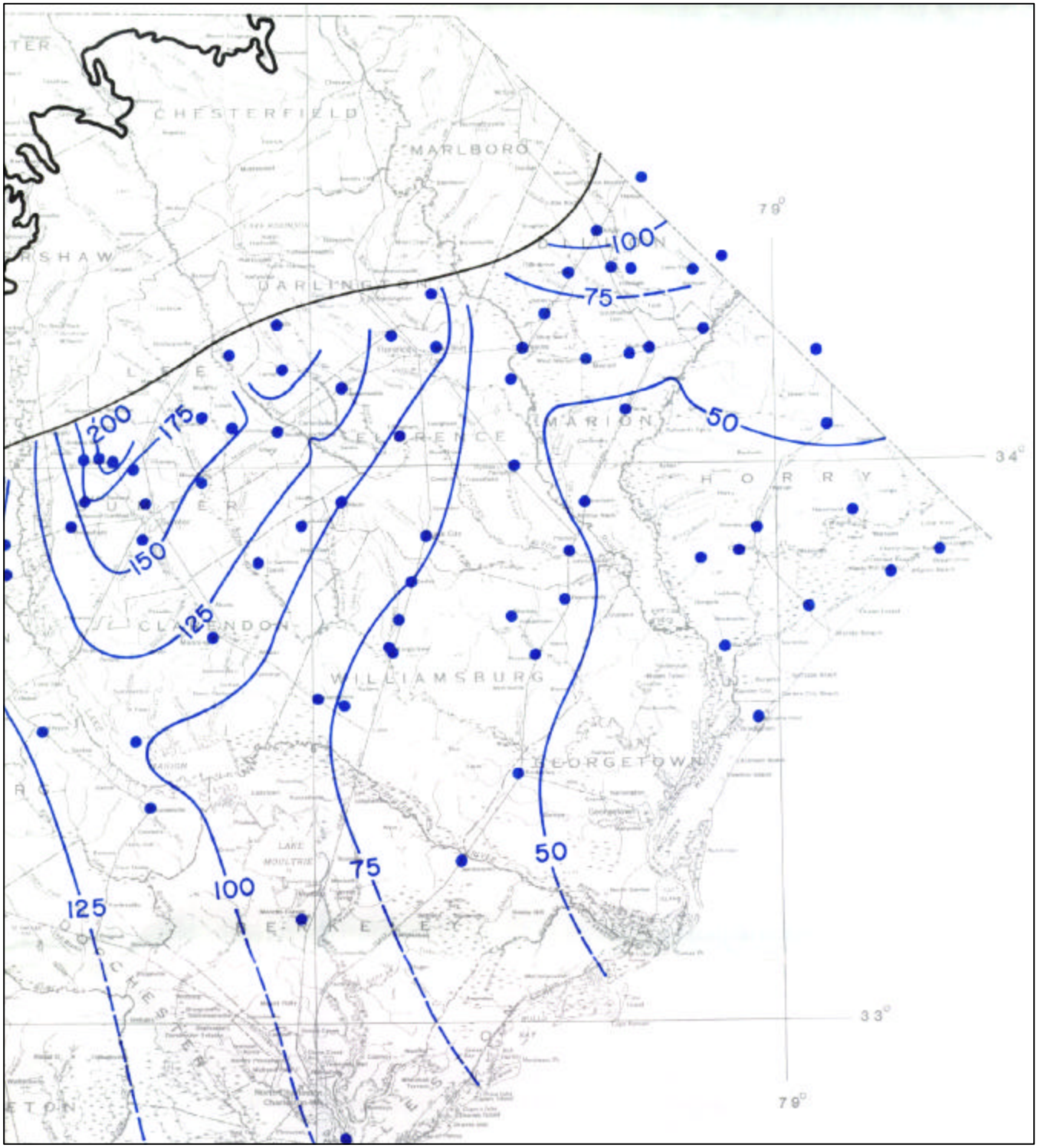

Figure 9. Potentiometric surface of the Black Creek, prior to development (from Aucott and Speiran, 1985)

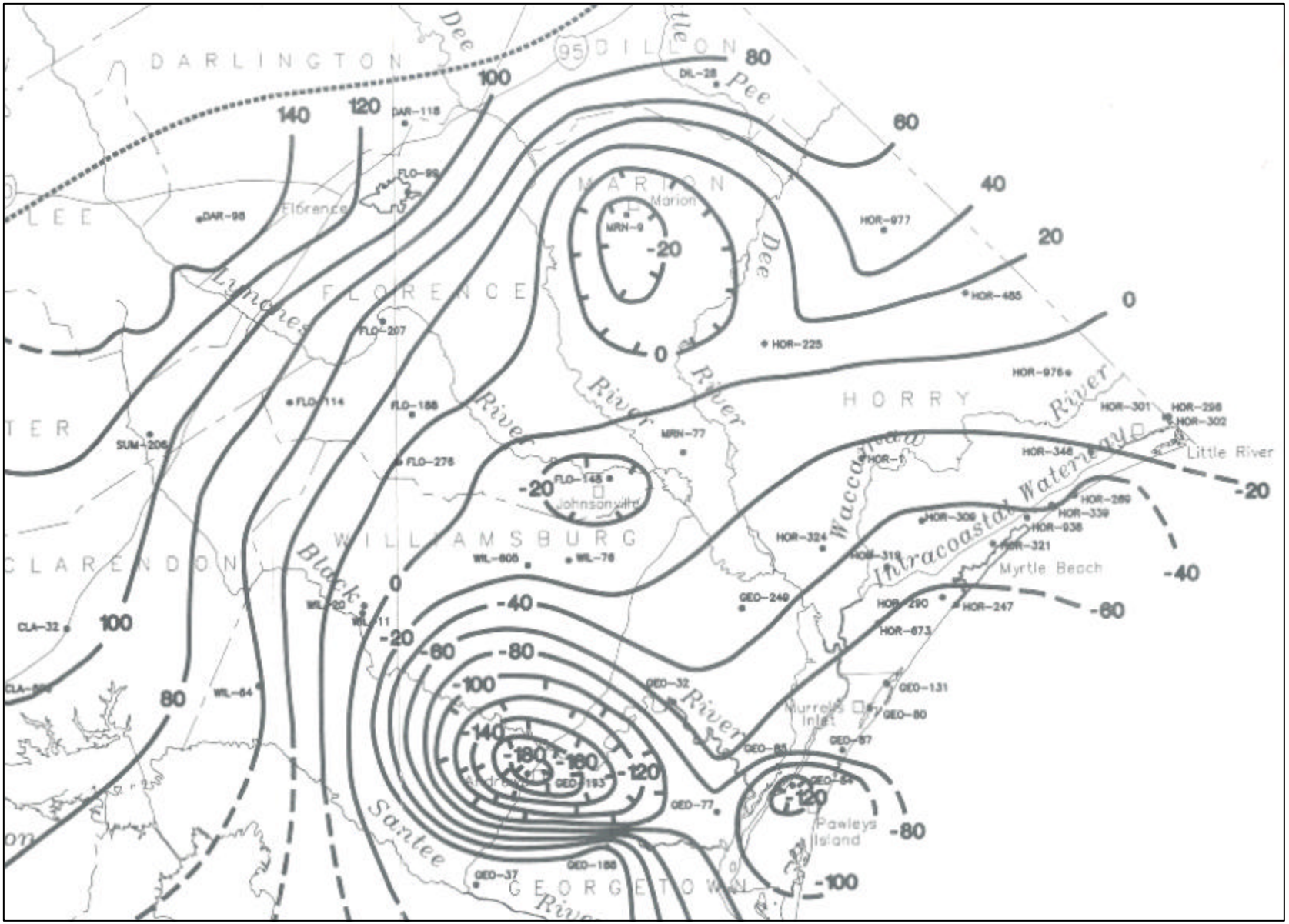

Figure 10. Potentiometric surface of the Black Creek aquifer in South Carolina – November 1995 (from Hockensmith, 1997)

The area experiencing the greatest decline in water levels in the Black Creek is the area around the Town of Andrews, just across the Williamsburg County line in Georgetown County. Predevelopment levels were approximately 55 feet above mean sea level. By 1995, they had declined to 198 feet below mean sea level; a decline of 253 feet. When measured in November 2001, however, they had recovered to about 154 feet below mean sea level (Hockensmith: personal communication, 2002). The reason for this recovery is unknown at this time.

Figure 11 shows the Trigger Levels for the Black Creek aquifer. SCDNR has determined that the Trigger Level is a water-level decline equal to 150 feet below the predevelopment water level of an aquifer. As can be seen by comparing figure 10 with figure 11, the area around Andrews is the only region in the study area that exceeds the Trigger Level. The Trigger Level for the Black Creek aquifer in the vicinity of Andrews is around 90 feet below mean sea level; in 2001, water levels were about 64 feet below the Trigger Level.

CONCLUSIONS AND RECOMMENDATIONS

Based on the technical data available, which have been summarized in this report, Department staff concludes that the Pee Dee area has developed and utilized groundwater to the degree that coordination and regulation of groundwater supplies has become desirable and necessary. Therefore, staff recommends designating six counties of the Pee Dee region a Capacity Use Area. Because Florence, Darlington, Marion, Marlboro, Dillon and Williamsburg Counties all share the same groundwater resources, and because all of the groundwater regimes in the area are indicating some degree of stress, it is appropriate that all six counties be included in the designation. This would be consistent with the Lowcountry Capacity Use Area (Beaufort, Jasper, and Colleton Counties), the Waccamaw Capacity Use Area(Georgetown, Horry, and part of Marion Counties), and the Trident Capacity Use Area (Berkeley, Charleston, and Dorchester Counties). Once designated, the Pee Dee Capacity Use Area, in conjunction with the Lowcountry, Waccamaw and Trident areas, will afford a mechanism by which the aquifers underlying coastal counties in South Carolina may be offered some degree of protection. This designation will also provide for measures to prevent, or at least mitigate, unreasonable adverse effects on water users and water uses within the Pee Dee Capacity Use Area.

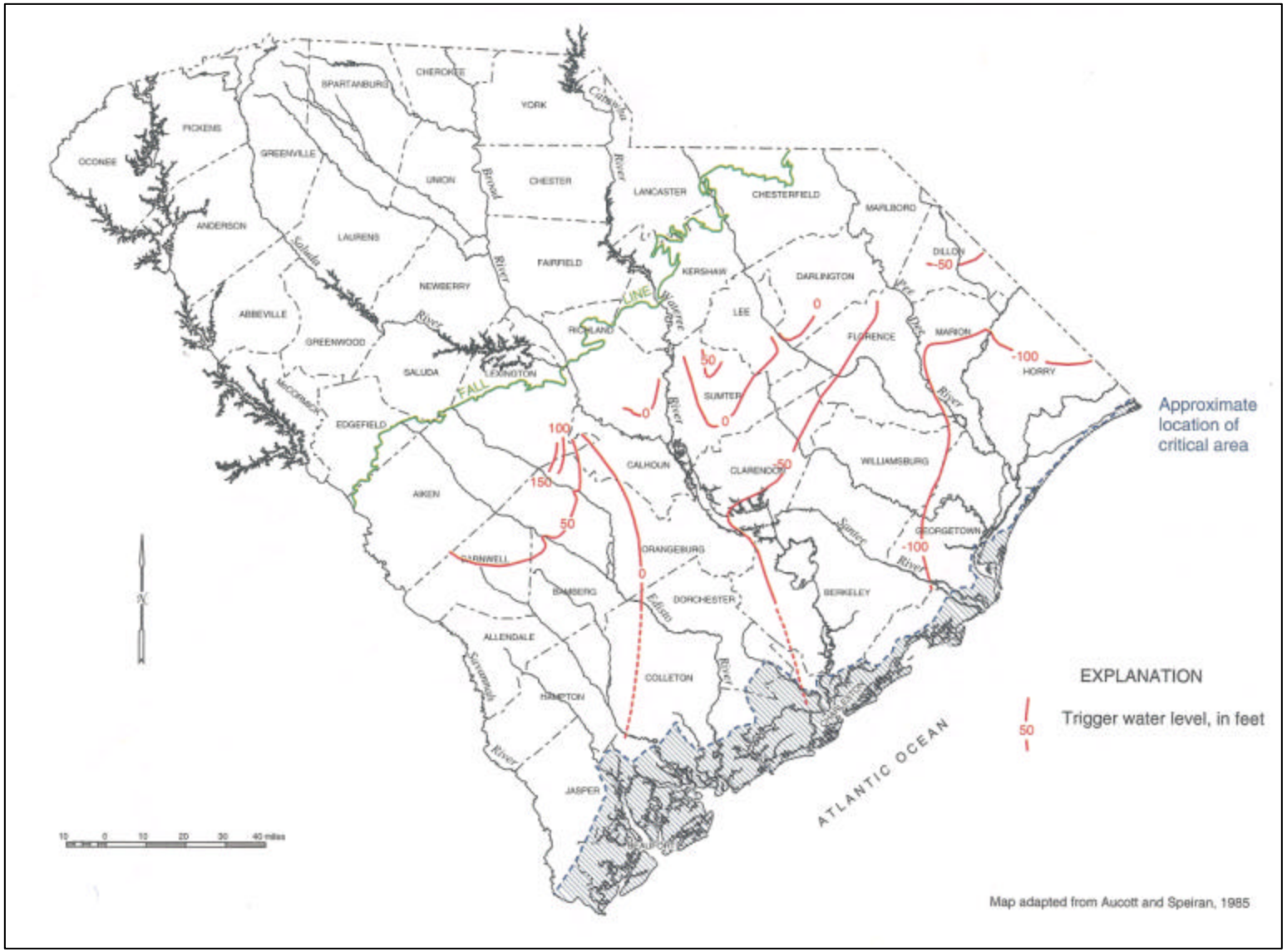

Figure 11. Trigger Levels for the Black Creek aquifer (from SCDNR, 1998)

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